

Radford Army Ammunition Plant
Radford Vicinity
Montgomery County
Virginia

HAER No. VA-37

HAER
VA,
61-RAD.V,
1-

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, DC 20013-7127

HAER
VA,
61-RAD.V,
1-

HISTORIC AMERICAN ENGINEERING RECORD

Radford Army Ammunition Plant

VA-37

Location: In the New River valley of southwestern Virginia. The Radford unit is in Montgomery County near the city of Radford and the New River unit in Pulaski County near the village of Dublin.

Date of Construction: Established in 1940.

Owner: Department of the Army

Significance: Established at the onset of World War II, the Radford unit was one of the first single-base smokeless-powder plants authorized under the Natural Defense Program and served as a planning model for similar installations. The New River unit was originally a separate installation constructed in 1941 as a bag-manufacturing-and-loading plant for smokeless and black powders. Following the war these two units were combined into a single installation.

Historical Report
Prepared by: Robert C. Mack and Jeffrey a. Hess.

Prepared for
Transmittal by: Robie S. Lange, HABS/HAER, 1985.

EXECUTIVE SUMMARY

The Radford Army Ammunition Plant (RAAP) is a government-owned, contractor-operated installation located in the New River Valley of southwestern Virginia. The installation is part of the Army's Armament, Munitions and Chemical Command (AMCCOM). The facility consists of two units: the 4111-acre Radford Unit near the city of Radford and the 2840-acre New River Unit near the village of Dublin. Constructed during 1940-1941, the Radford Unit was one of the first single-base smokeless-powder plants authorized under the National Defense Program and served as a planning model for similar installations. It was expanded throughout World War II with the addition of facilities for manufacturing TNT, nitroglycerin, pentolite, double-base rocket-propellants, and mortar increments. The New River Unit, which originally was a separate installation, was constructed 1941-42 as a bag-manufacturing-and-loading plant for smokeless and black powders. Following World War II, the two units were combined into a single installation and designated a standby facility. The RAAP was reactivated and extensively renovated during the Korean War and has remained active since that time. Beginning in the late 1960s, the Radford Unit underwent further expansion with the construction of new continuous-process facilities for the manufacture of TNT, and single- and multi-base propellants. During this same period extensive portions of the New River Unit, including all the manufacturing buildings, were sold.

The RAAP includes approximately 1,230 buildings: 1,050 at the Radford unit and 180 at the New River Unit. Of these, nearly 90% date from the World War II period. Neither location retains any buildings which predate World

War II. Apart from the modernization projects of the 1960s and 1970s RAAP buildings and equipment have experienced little modification since World War II and still reflect their original design and purpose. There are, however, no Category I, II, or III historic properties at RAAP.

CONTENTS

Executive Summary

PREFACE	1
1. INTRODUCTION	3
Scope	3
Methodology	4
2. HISTORICAL OVERVIEW	14
Background	14
World War II	17
Post-World War II	30
Korean War	31
Vietnam War to the Present	32
3. PRESERVATION RECOMMENDATIONS	37
Background	37
Category I Historic Properties	42
Category II Historic Properties	42
Category III Historic Properties	43
BIBLIOGRAPHY	44
Appendix A	

PREFACE

This report presents the results of an historic properties survey of the Radford Army Ammunition Plant (RAAP). Prepared for the United States Army Materiel Development and Readiness Command (DARCOM), the report is intended to assist the Army in bringing this installation into compliance with the National Historic Preservation Act of 1966 and its amendments, and related federal laws and regulations. To this end, the report focuses on the identification, evaluation, documentation, nomination, and preservation of historic properties at the RAAP. Chapter 1 sets forth the survey's scope and methodology; Chapter 2 presents an architectural, historical, and technological overview of the installation and its properties; and Chapter 3 identifies significant properties by Army category and sets forth preservation recommendations. Illustrations and an annotated bibliography supplement the text.

This report is part of a program initiated through a memorandum of agreement between the National Park Service, Department of the Interior, and the U.S. Department of the Army. The program covers 74 DARCOM installations and has two components: 1) a survey of historic properties (districts, buildings, structures, and objects), and 2) the development of archaeological overviews. Stanley H. Fried, Chief, Real Estate Branch of Headquarters DARCOM, directed the program for the Army, and Dr. Robert J. Kapsch, Chief of the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) directed the program for the National Park Service. Sally Kress Tompkins was program manager, and Robie S. Lange was

project manager for the historic properties survey. Technical assistance was provided by Donald C. Jackson.

Building Technology Incorporated acted as primary contractor to HABS/HAER for the historic properties survey. William A. Brenner was BTI's principal-in-charge and Dr. Larry D. Lankton was the chief technical consultant. Major subcontractors were the MacDonald and Mack Partnership and Jeffrey A. Hess. The authors of this report were Robert C. Mack and Jeffrey A. Hess. They would like to thank the many employees at the RAAP who graciously assisted in the research and field surveys. They especially acknowledge the help of the following individuals: on the government staff, Capt. Michael Coleman, Executive Officer; Frances Selnow, Administrative Officer; and Doyle Akers, Engineering Technician; and on the Hercules, Inc., staff, James Nelson, Chief of the Standby and Layaway Division; and C.T. Lane.

The complete HABS/HAER documentation for this installation will be included in the HABS/HAER collections at the Library of Congress, Prints and Photographs Division, under the designation HAER No. VA-37.

Chapter 1

INTRODUCTION

SCOPE

This report is based on an historic properties survey conducted in December 1983 of all Army-owned properties located within the official boundaries of the Radford Army Ammunition Plant (RAAP). The survey included the following tasks:

- . Completion of documentary research on the history of the installation and its properties.
- . Completion of a field inventory of all properties at the installation.
- . Preparation of a combined architectural, historical, and technological overview for the installation.
- . Evaluation of historic properties and development of recommendations for preservation of these properties.

Also completed as a part of the historic properties survey of the installation, but not included in this report, are HABS/HAER Inventory cards for 31 individual properties. These cards, which constitute HABS/HAER Documentation Level IV, will be provided to the Department of the Army. Archival copies of the cards, with their accompanying photographic

negatives, will be transmitted to the HABS/HAER collections at the Library of Congress.

The methodology used to complete these tasks is described in the following section of this report.

METHODOLOGY

1. Documentary Research

The RAAP was constructed during 1940-1945 as two distinct production facilities: a smokeless-powder plant (Radford Ordnance Works) and a bag-manufacturing-and-loading plant for artillery, cannon, and mortar projectiles (New River Ordnance Works). Since more than a dozen installations around the country were involved with similar operations, an evaluation of the RAAP's historical significance requires a general understanding of the American wartime munitions industry. To identify relevant published sources, research was conducted in standard bibliographies of military history, engineering, and the applied sciences. Unpublished sources were identified by researching the historical and technological archives of the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) at Rock Island Arsenal.¹

In addition to such industry-wide research, a concerted effort was made to locate published sources dealing specifically with the history and technology of the RAAP. This site-specific research was conducted primarily at the AMCCOM Historical Office at Rock Island Arsenal; the

Radford Public Library in Radford, Virginia; the New River Valley Historical Society in Newbern, Virginia; and the government and contractor archives at the RAAP. The Virginia State Historic Preservation Office (Virginia Historic Landmarks Commission, Richmond) was also contacted for information on the architecture, history, and technology of the RAAP, but provided no pertinent data.

Army records used for the field inventory included current Real Property Inventory (RPI) printouts that listed all officially recorded buildings and structures by facility classification and date of construction; the installation's property record cards; base maps and photographs supplied by installation personnel; and installation master planning, archaeological, environmental assessment, and related reports and documents. A complete listing of this documentary material may be found in the bibliography.

2. Field Inventory

Architectural and technological field surveys were conducted in December 1983 by Robert C. Mack. Following general discussions with Doyle Akers, Engineering Technician for the government, and James Nelson, Chief of Standby and Layaway for Hercules, Inc., the surveyor was provided with escorts for a general field survey of all exterior areas of the installation and for a tour of selected manufacturing buildings. James Nelson and Doyle Akers served as guides for the general field survey of the Radford and New River areas respectively.

C.T. Lane served as guide for the smokeless-powder manufacturing buildings.

Field inventory procedures were based on the HABS/HAER Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures.² All areas and properties were visually surveyed. Building locations and approximate dates of construction were noted from the installation's property records and field-verified. Due to safety and security concerns, most production areas could be viewed only from main roads. No photography was permitted at RAAP. (See Appendix A.) Interior surveys were permitted of only one smokeless-powder manufacturing line to permit evaluation of architectural features, building technology, and production equipment.

Field inventory forms were prepared for pre-1946 buildings and structures where inspection was permitted. When groups of similar ("prototypical") buildings were found, one field form was normally prepared to represent all buildings of that type. Field inventory forms were also completed for representative post-1945 buildings and structures where inspection was permitted.³ Information collected on the field forms was later evaluated, condensed, and transferred to HABS/HAER Inventory cards.

3. Historical Overview

A combined architectural, historical, and technological overview was prepared from information developed from the documentary research and

the field inventory. It was written in two parts: 1) an introductory description of the installation, and 2) a history of the installation by periods of development, beginning with pre-military land uses. Maps and photographs were selected to supplement the text as appropriate.

The objectives of the overview were to 1) establish the periods of major construction at the installation, 2) identify important events and individuals associated with specific historic properties, 3) describe patterns and locations of historic property types, and 4) analyze specific building and industrial technologies employed at the installation.

4. Property Evaluation and Preservation Measures

Based on information developed in the historical overviews, properties were first evaluated for historical significance in accordance with the eligibility criteria for nomination to the National Register of Historic Places. These criteria require that eligible properties possess integrity of location, design, setting, materials, workmanship, feeling, and association, and that they meet one or more of the following:⁴

- A. Are associated with events that have made a significant contribution to the broad patterns of our history.

- B. Are associated with the lives of persons significant in the nation's past.
- C. Embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.
- D. Have yielded, or may be likely to yield, information important in pre-history or history.

Properties thus evaluated were further assessed for placement in one of five Army historic property categories as described in Army Regulation 420-40:⁵

- Category I Properties of major importance
- Category II Properties of importance
- Category III Properties of minor importance
- Category IV Properties of little or no importance
- Category V Properties detrimental to the significance of adjacent historic properties.

Based on an extensive review of the architectural, historical, and technological resources identified on DARCOM installations nationwide, four criteria were developed to help determine the appropriate categorization level for each Army property. These criteria were used

to assess the importance not only of properties of traditional historical interest, but also of the vast number of standardized or prototypical buildings, structures and production processes that were built and put into service during World War II, as well as of properties associated with many post-war technological achievements. The four criteria were often used in combination and are as follows:

- 1) Degree of importance as a work of architectural, engineering, or industrial design. This criterion took into account the qualitative factors by which design is normally judged: artistic merit, workmanship, appropriate use of materials, and functionality.
- 2) Degree of rarity as a remaining example of a once widely used architectural, engineering, or industrial design or process. This criterion was applied primarily to the many standardized or prototypical DARCOM buildings, structures, or industrial processes. The more widespread or influential the design or process, the greater the importance of the remaining examples of the design or process was considered to be. This criterion was also used for non-military structures such as farmhouses and other once prevalent building types.
- 3) Degree of integrity or completeness. This criterion compared the current condition, appearance, and function of a building, structure, architectural assemblage, or industrial process to its original or most historically important

condition, appearance, and function. Those properties that were highly intact were generally considered of greater importance than those that were not.

- 4) Degree of association with an important person, program, or event. This criterion was used to examine the relationship of a property to a famous personage, wartime project, or similar factor that lent the property special importance.

The majority of DARCOM properties were built just prior to or during World War II, and special attention was given to their evaluation. Those that still remain do not often possess individual importance, but collectively they represent the remnants of a vast construction undertaking whose architectural, historical, and technological importance needed to be assessed before their numbers diminished further. This assessment centered on an extensive review of the military construction of the 1940-1945 period, and its contribution to the history of World War II and the post-war Army landscape.

Because technology has advanced so rapidly since the war, post-World War II properties were also given attention. These properties were evaluated in terms of the nation's more recent accomplishments in weaponry, rocketry, electronics, and related technological and scientific endeavors. Thus the traditional definition of "historic" as a property 50 or more years old was not germane in the assessment of either World War II or post-war DARCOM buildings and structures;

rather, the historic importance of all properties was evaluated as completely as possible regardless of age.

Property designations by category are expected to be useful for approximately ten years, after which all categorizations should be reviewed and updated.

Following this categorization procedure, Category I, II, and III historic properties were analyzed in terms of:

- Current structural condition and state of repair. This information was taken from the field inventory forms and photographs, and was often supplemented by rechecking with facilities engineering personnel.
- The nature of possible future adverse impacts to the property. This information was gathered from the installation's master planning documents and rechecked with facilities engineering personnel.

Based on the above considerations, the general preservation recommendations presented in Chapter 3 for Category I, II, and III historic properties were developed. Special preservation recommendations were created for individual properties as circumstances required.

5. Report Review

Prior to being completed in final form, this report was subjected to an in-house review by Building Technology Incorporated. It was then sent in draft to the subject installation for comment and clearance and, with its associated historical materials, to HABS/HAER staff for technical review. When the installation cleared the report, additional draft copies were sent to DARCOM, the appropriate State Historic Preservation Officer, and, when requested, to the archaeological contractor performing parallel work at the installation. The report was revised based on all comments collected, then published in final form.

NOTES

1. The following bibliographies of published sources were consulted: Industrial Arts Index, 1938-1957; Applied Science and Technology Index, 1958-1980; Engineering Index, 1938-1983; Robin Higham, ed., A Guide to the Sources of United States Military History (Hamden, Conn.: Archon Books, 1975); John E. Jessup and Robert W. Coakley, A Guide to the Study and Use of Military History (Washington, D.C.: U.S. Government Printing Office, 1979); "Military Installations," Public Works History in the United States, eds., Suellen M. Hoy and Michael C. Robinson (Nashville: American Association for State and Local History, 1982), pp. 380-400. AMCCOM (formerly ARRCOM, or U.S. Army Armament Materiel Readiness Command) is the military agency responsible for supervising the operation of government-owned munitions plants; its headquarters are located at Rock Island Arsenal, Rock Island, Illinois. Although there is no comprehensive index to AMCCOM archival holdings, the agency's microfiche collection of unpublished reports is itemized in ARRCOM, Catalog of Common Sources, Fiscal Year 1983, 2 vols. (no pl.: Historical Office, AMCCOM, Rock Island Arsenal, n.d.).
2. Historic American Buildings Survey/Historic American Engineering Record, National Park Service, Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures (unpublished draft, 1982).

3. Representative post-World War II buildings and structures were defined as properties that were: (a) "representative" by virtue of construction type, architectural type, function, or a combination of these, (b) of obvious Category I, II, or III historic importance, or (c) prominent on the installation by virtue of size, location, or other distinctive feature.
4. National Park Service, How to Complete National Register Forms (Washington, D.C.: U.S. Government Printing Office, January 1977).
5. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

Chapter 2

HISTORICAL OVERVIEW

BACKGROUND

The Radford Army Ammunition Plant (RAAP) is a government-owned, contractor-operated (GOCO) installation located in the New River Valley of southwestern Virginia. The plant is composed of two units: the 4,111 acre Radford Unit, near Radford, Virginia (Figure 1), and the 2,840 acre New River Unit near Dublin, Virginia (Figure 2).^{*} Constructed during 1940-1941, the Radford Unit was one of the first single-base, smokeless-powder plants authorized under the National Defense Program, and it served as a planning model for similar installations. Initial construction included facilities for manufacturing and forming double-base powder. The plant expanded throughout World War II with the addition of facilities to manufacture pentolite, black powder, triple-base powder, rolled powder, TNT, and nitroglycerine. The New River unit was constructed in 1941-1942 as a bag-manufacturing-and-loading plant. After World War II, both units became standby facilities, although the Radford Unit was used for production of ammonium nitrate fertilizer.

^{*} During World War II, the Radford Ordnance Works (ROW) and the New River Ordnance Works (NROW) were operated as separate production plants. Late in 1945 ROW was designated the "Radford Arsenal" with the NROW as a sub-post. In January 1950 the sub-post designation was eliminated and the former NROW became an integral part of the Arsenal. In 1961 the installation was renamed the Radford Ordnance Plant and remained so until it was designated the Radford Ammunition Plant (RAAP) in August 1963. For purposes of brevity and clarity, this report will refer to the Radford Unit and New River Unit as the RAAP.



Figure 1: RAAP, Radford Unit. Site map as of March 1982, based on original layout. (Source: Government files, RAAP.)

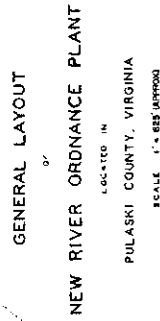


Figure 2: RAAP, New River Unit. Site map as of September 1982, based on original layout. Shaded areas have been transferred from DAROM ownership; note that these areas include nearly all the original industrial portions of the plant. (Source: Government files, RAAP.)

The Radford Unit underwent rehabilitation and expansion in the early 1950s in conjunction with major production runs, and the plant has remained active since that time. Modernization began in 1968 with the construction of a new TNT plant and continued in the 1970s with construction of new acid facilities and continuous-process lines for nitrocellulose, single-base propellants, and multiple-base propellants.

Currently, the RAAP comprises approximately 1230 buildings: 1050 at the Radford unit and 180 at the New River unit. Of these, about 1090 (88%) date from the World-War-II construction period. Apart from the modernization projects of the 1960s and 70s, the RAAP's production lines still reflect standard, World-War-II, manufacturing practices.

WORLD WAR II

Although the United States built an extensive munitions-manufacturing network during World War I, few facilities survived the country's "return to normalcy" and disarmament of the 1920s. The dismantling of powder and explosives works was particularly thorough. By the mid-1930s, there were only four active plants for manufacturing single-base smokeless powder, the primary propellant for American military ammunition. Two of these installations were owned and operated by the federal government: the Army's Picatinny Arsenal in New Jersey, and the Navy's Indian Head Plant in Maryland. The other two, both located in New Jersey, were owned by private industry: the Carney's Point Plant of du Pont de Nemours & Co, Inc., and the Kenvil Plant of Hercules Powder Co., Inc. Although these facilities employed modern manufacturing techniques, their combined capacities were

barely equal to the task of supplying the nation's peacetime armed forces. As a first step toward expanding American smokeless-powder capability, the U.S. Ordnance Department in 1937-1938 requested Hercules and du Pont to assist in the preparation of engineering specifications for a series of new plants. At the same time, the government began stockpiling "powder machinery and specialized equipment . . . that might not be readily available in an emergency."¹ The emergency came with the fall of France in the summer of 1940, when Congress appropriated defense funds for three new powder plants. Because of the Ordnance Department's advance planning, two of the three installations were in operation by 1941. The RAAP was constructed as part of this initial defense program.²

Site Selection and Former Land Use

Radford Unit: The selection of the primary site for the RAAP was governed by the same basic criteria used in evaluating locations for all three of the new powder plants. These considerations included:

- 1) a southern location to ensure easy access to cotton, a basic raw material for smokeless-powder production
- 2) access to coal suitable for steam production
- 3) a mid-continental location as a defense against enemy bombardment
- 4) proximity to two main railroad lines
- 5) availability of an ample water supply for processing purposes
- 6) a relatively level site to avoid excessive grading
- 7) availability of suitable labor.³

Although the actual design and construction of the Radford Unit did not begin until 1940, the Army had begun site selection procedures several years earlier. A tentative decision to use the site was made following an inspection trip in September 1939.⁴ Although the site was somewhat hilly, it met all the other criteria. In addition, it had seen limited development: only 40 farms, primarily for raising corn, existed on the site.⁵ None of the pre-World War II structures survive.

New River Unit: Original plans called for a bag-manufacturing-and-loading plant in the Horseshoe Bend Area of the Radford Unit. Early design changes mandated, however, that the Horseshoe Bend Area be used for other purposes. It was necessary, therefore, to find a new location for the bag-manufacturing-and-loading plant. The search for a site began in November 1940 and was concluded several months later with the selection of approximately 4,000 acres near the village of Dublin, about 12 miles from the city of Radford. This site, too, was limited to agricultural use: it encompassed 45 tracts of farms and rural homesteads.⁶ No pre-World-War-II structures survive.

Construction

Radford Unit: The smokeless-powder facility was the first to be planned and built. Construction began on August 23, 1940, under the general supervision of the Quartermaster Corps.⁷ The Hercules Powder Company of Wilmington, Delaware, was awarded the contract for both design and construction of the project; the Mason and Hangar Company served as primary

subcontractor for construction. By the end of the initial phase of construction in late 1941, the plant consisted of 687 buildings, nearly two-thirds of which were production buildings.⁸ At the cessation of hostilities in 1945, the plant had expanded to approximately 870 buildings, including nearly 500 production facilities.⁹

The Radford Unit was divided into two primary areas: the "Main Plant Site" on the south side of the river, and the "Horseshoe Bend Area" enclosed in a large bend in the river. The original design of the plant called for six smokeless-powder lines on the Main Plant Site, with the bag-manufacturing-and-loading plant and storage magazines in the Horseshoe Bend Area. Following a major explosion at the Kenvil, New Jersey, powder plant, the RAAP was redesigned to increase distances between buildings. To accommodate these changes it was necessary to re-locate the bag-loading facility and to reduce the smokeless-powder area to three lines.¹⁰

The Main Plant Site was designed around the central Power House (Building 400), which furnished both electricity and steam. Clustered immediately around this structure were the Acid Area, Administration Area, and Shops Area, with the principal production facilities to the north. The Acid Area originally included facilities for manufacturing nitric acid (Buildings 702, 703) and concentrating sulphuric acid (Building 704). The administrative compound contained the old Main Administration Building (Building 200), Telephone Exchange (Building 263), Hospital (Building 205), and similar support facilities. The Shops Area contained a large Combined Shops structure (Building 500) and numerous other small specialty shops and storage facilities. The smokeless-powder manufacturing facilities were

constructed in three parallel "lines" (A, B, and C) between the power plant and the river. As the war progressed, additional facilities were constructed flanking the original development. Complexes for manufacturing nitroglycerin (Buildings 3614-3638), TNT (Buildings 4500-4510), and rolled powder (Buildings 3700-3749) were added to the west, while a pentolite manufacturing area (Buildings 4000-4020) was added to the east.¹¹ At this same time, the "C" line was adapted for the manufacture of double-base powder. Near the close of the war, three complexes for production of mortar increments (small discs of propellant used in groups) were begun, one to the west of the earlier development (Buildings 7104 - 7220) and two to the east (Buildings 9309-9378); only two of three complexes were completed.¹²

The buildings were strictly utilitarian, and even the most public buildings incorporated no pretensions of style. The Administration Building (Building 200), Hospital (Building 205), and other administrative buildings were constructed of heavy timber with exterior walls of concrete block; roofs were simple gables with built-up roofing. Shop structures, such as the Combined Shops (Building 500) were steel frame with brick exterior walls; here, too, roofs were gabled with built-up roofing.¹³

The design and materials of the production buildings reflected the nature of the powder at each stage of production:

[Buildings] used in the first stage of the process, where the material handled is highly inflammable but not explosive, are grouped together in a section known as the "cotton area." Those used in the second stage, where the material handled is highly explosive, are widely spaced and form what is called the "powder line." Material is conveyed from one building to another first by flumes, then by motor

trucks, and finally — when the highly explosive stage is reached — by small hand carts.

The Nitrocellulose Area [1000, 2000, and 3000 series buildings] . . . must guard against two main hazards, fire and acid burns. Cotton in itself is very inflammable, but after being nitrated, this hazard increases many times. The nitrating process is therefore housed in fireproof masonry and steel construction. Next, the nitrated cotton goes through a number of processes suspended in water, a state in which it is not explosive nor is it readily fired. Since the prime requirement of all these houses is shielding which will prevent the accumulation of cotton dust, wood frame construction covered with galvanized iron is used.

From the Nitrocotton Area the material passes into the Powder Area [1500, 2500, and 3500 series buildings]. From here on a unique type of construction, adapted to handling of explosive materials, is required. All of the buildings in the powder line make use of "blow out" construction designed to control the direction of an explosion through one or more extremely light screens which will "blow-out" with a minimum increase in the air pressure within the building.

A second method of limiting the effects of explosions . . . is used in the solvent recovery buildings [1600 series buildings] and those in the finishing area [1700 series buildings], which are spaced from all other buildings and from each other and surrounded by barricades. Spacing varies according to the maximum amount of explosive which is to be processed or stored in the building at any one time.

Barricades are constructed of heavy timbers with a plank face on each side and a screened dirt fill, making a solid wall with an average of approximately 5-foot thickness to absorb the shock of any possible explosion. Their height roughly corresponds to the height of the buildings they surround.¹⁴

As finally laid out in 1940, the Horseshoe Bend Area included storage magazines (Buildings 1909-1954) for both cannon and small arms propellants at its east end, and test ranges for cannon powder and mortar increments to the southwest. The magazines were wood frame buildings with gabled shingle roofs; they were surrounded by barricades similar to those used on the production lines. Following completion of the original facilities in this

area, two pilot plants were constructed. Pilot Plant A (Buildings 5001-5016), was completed in 1942, for produced rocket propellants; Pilot Plant B, also completed in 1942, was designed for forced-air drying of double-base propellant grains.¹⁵

A group of 20 two-story, wood-frame residences (Buildings 2-1 through 4-4) was constructed south of the Main Plant Area for key government and contractor employees. An additional 43 residences were erected in the city of Radford for use by contractor employees.¹⁶

New River Unit: On February 10, 1941, construction began on a bag-manufacturing-and-loading plant approximately 12 miles from the Radford Unit. The plant was designed by the Hercules Powder Company; construction was by the Mason and Hangar Company under direct contract with the government. The original plan called for four propellant-charge bag-loading lines (Buildings 401-472), two igniter-charge bag-loading lines (Buildings 502, and 524), a bag manufacturing building (Building 205), administrative and shop support buildings, and staff residences (Buildings 1-15). In addition, there were to be storage magazines for a 30 days' supply of incoming material and a 60 days' supply of finished products; this requirement translated to 87 smokeless-powder magazines (Buildings 1107, and 1113-2113), two black powder magazines (Buildings 1109, 1111), and 59 high explosives magazines (Buildings 4603-1 through 4603-59).¹⁷

As at the Radford Unit, expansion of the New River Unit continued throughout the war. Additional facilities included flash-reducer loading lines

(Buildings 8102-1 through 8102-8), black-powder drying facilities (Buildings 8121-8128), and a fifth bag-loading line (Buildings 8500-8516).¹⁸

For the most part, the design of the production buildings conformed to standardized specifications developed by the Ordnance Department for all bag-loading plants. The bag-loading lines, for example, employed typical "blow-out" construction similar to the powder-line buildings. The only building to deviate from standard designs was the bag-manufacturing building (Building 205), a large single-story building patterned after a similar building at the Hoosier Ordnance Works.¹⁹

Technology

The term "smokeless powder" is a double misnomer. The material is actually a granulated substance, smokeless chiefly in comparison to black powder, which it replaced as the standard military propellant during the late nineteenth-century. Smokeless powder is categorized, according to the number of its active ingredients, as single-, double-, triple- or multiple-base. Single-base powder, adopted by the American military for cannon and small arms during both World Wars, derives its propellant qualities from nitrocellulose. The modern manufacture of single-base powder still resembles the pioneering method developed by the French chemist Vielle in 1886. Vielle treated cotton with nitric acid to form nitrocellulose, gelatinized it with ether or alcohol, then dried and cut the resulting material into "grains." Subsequent improvements on Vielle's method included the perforation of powder grains to increase surface area and burning rate, and the use of chemical additives as stabilizers and

flash retardants. In the summer of 1940, the Ordnance Department codified production methods for smokeless powder in a technical manual that dictated operating procedures at the RAAP and most other World-War-II plants.²⁰

Under the contract supervision of Hercules, the RAAP began smokeless-powder production in April 1941, and remained in operation until October 1945. The smokeless-powder area consisted of three parallel lines, designated (east to west) A through C. The RAAP lines were unique among smokeless-powder plants: all lines were interconnected, allowing transfer of materials from one line to another at each major step in the production process.²¹ Although Line C quickly was adapted for production of double-base propellants, all three lines originally produced a variety of single-base grain sizes and configurations. The basic process is summarized in this description of propellant manufacturing at the RAAP:

The nitration of purified cotton, the first step at the Radford Plant, is accomplished by adding mixed sulphuric and nitric acids to cotton linters [in the Nitrating House, Building 1012].²² After nitration the nitrocellulose is pumped to a centrifugal wringer revolving at a speed of 1,100 r.p.m. where as much of the excess acid as possible is extracted. It is then "drowned" in cold water and moved to the boiling tubs [in the Boiling Tub House, Building 1019].

The nitrocellulose is next boiled in acidulated water to break down the unwanted chemical compounds which have formed in the process. After this it is transferred to beating or cutting machines [in the Beater House, Building 1022] where it is ground under water. This finely ground or pulped nitrocellulose is boiled in alkaline and fresh water [in the Poacher and Blending House, Building 1024] then given cold water washings to remove all impurities. [Centrifugal wringers in the Wringer House, Building 1026, remove the free water.]

At this point the nitrocellulose enters the actual "powder line." In the dehydration house [Building 1500] a charge of wet nitrocellulose is dumped into a hydraulic press and compressed into a block. Alcohol is pumped through the

block in the press forcing out the water. Much higher pressure is then applied which presses out most of the alcohol.

The dehydrated nitrocellulose is sent to a block breaker [in the Mix House, Building 1508], which breaks the block into small pieces. This material then goes to the mixing machine . . . where ether and alcohol and certain stabilizing chemicals are added, and the ingredients mixed until a mealy mass is formed; and this is more thoroughly mixed in the macerators. The mixed powder is then dumped into a preliminary block-forming press [in the Block Press House, Building 1510] and under pressure formed into blocks 12 in. in diameter and 24 in. long. The blocks are placed in a "macaroni" press, where the powder is forced through a fine mesh screen. The material is then reblocked in a press similar to the preliminary block-forming press.

One or two blocks are put into the finishing press [in the Finishing Press House, Building 1513], subjected to a pressure of several thousand pounds per square inch, pressed through dies and forced out in long spaghetti-like strings into fiber buckets. These strings have either one or seven longitudinal holes formed by the dies. The strings are fed into cutting machines [in the Cutting House, Building 1513A], which cut them into grains of the desired lengths. The diameter and length of the grains are varied according to the ballistic characteristics required.

The powder grains are then conveyed to the solvent recovery building [Building 1622] where they are treated for several days and most of the ether and alcohol recovered. As the powder still contains too much solvents [sic.] for use, it is taken to the "water dry" [House, Building 1660] where it is placed in hot water. When the solvent content has been reduced sufficiently, the powder is placed in the air dry house [Building 1726] where warm air blown over and through the powder dries it further.

Cannon powders require no glazing, but rifle powders are glazed with graphite [in the Glaze House, Building 1800] to make them flow freely. [The powder next goes to the Screening House, Building 1850, where rifle powder] is then sieved and cannon powder sorted to remove imperfect grains. The various batches are blended [in the Pre-Blending House, Building 1810] and in the Final Blending House, Building 1825] to obtain powder of uniform ballistics and finally²³ packed ready for storage and shipment to loading plants.

In addition to manufacturing finished propellant, the RAAP was also responsible for the manufacture of several basic raw materials, including

nitric acid and nitroglycerin. The nitric acid facilities were of standard industrial design, embodying a technology developed by du Pont in the mid-1920s. Liquid ammonia was vaporized and mixed with heated compressed air in the presence of a platinum catalyst to form nitrogen oxides. The nitrogen compounds were then further oxidized with air and fed into an absorption tower, where they combined with water to form 60% nitric acid (Buildings 700-702).²⁴ Like most industrial uses of nitric acid, the manufacture of nitrocellulose required an almost pure grade of the ingredient. To achieve this level of purity, the RAAP used the time-honored technique of concentrating the 60% nitric acid by dehydrating it with strong sulfuric acid (Building 703). The spent sulfuric acid, now diluted with water, was brought back to strength for recycling in the nitric acid operation.²⁵

The manufacture of nitroglycerin (NG) involved the nitration of glycerin in a mixed sulfuric-nitric acid solution called "nitroglycerin mixed acid" (NGMA). In the NG Nitrating and Separating House (Building 3630), glycerin was slowly added to a relatively large volume of NGMA; chilled brine was circulated through immersion coils to keep the mixture cool. Once fully mixed, the batch flowed to a separating tank where the spent acid settled to the bottom and was removed. The NG next was washed and emulsified, then moved in troughs to the Neutralizing House (Building 3637) where soda ash was used to remove residual acid. After final washing, the NG was ready to use.²⁶

The RAAP also constructed and operated its own utilities. The central Power House (Building 400) contained four 7,500-hp, coal-fired boilers to

produce comfort-and-process heating, and four turbo-generators for electricity. Water was drawn directly from the New River at the rate of 15 m.g.d., primarily for use in the manufacturing process. The electrical system also was connected to the local commercial power lines of the Appalachian Electric Power Co. in case of temporary shutdown of the power house.²⁷

Although there were no major alterations to the smokeless-powder facilities during World War II, the Radford Unit did experience technological expansion with the construction of an oleum plant and facilities for manufacturing rocket propellants, TNT (trinitrotoluene), pentolite (a mixture of TNT and pentaerythrite tetranitrate), and rolled powder. The rocket-propellant facilities merit further description.

Traditionally, rocket propellant production was essentially a size modification in the solvent-process of double-based powder manufacturing. In the autumn of 1942, however, Pilot Plant "A" (Buildings 5000-5016) was constructed for the manufacture and study of solventless extruded powders that could be made in much larger sizes than solvent powder. Information developed at this plant was incorporated into the construction of rocket lines at the Sunflower and Badger AAPs.²⁸ Solventless powder began with the same nitrocellulose used in other powders. Following dehydration, the nitrocellulose was carted to the Premix House (Building 5001), where nitroglycerin was added to make a paste. The mixture was rolled to align the fibers (Building 5003-1), then pressed through large dies on hydraulic presses (Building 5008-1) to create the large grains.²⁹

New River Unit: As was true for other propellant plants, the RAAP's smokeless-powder lines were in close proximity to bag-manufacturing-and-loading facilities, which produced finished propellant charges for artillery, cannon, and mortar projectiles. Production commenced in the fall of 1941 and continued until the summer of 1943, when operations were changed to waterproofing mortar increments.³⁰ The New River Unit had four identical lines (400 series buildings) for loading smokeless powder and two identical lines (Buildings 500 - 527) for loading black-powder igniter charges. Included with the black-powder lines were facilities for drying the powder prior to loading into bags (Buildings 561-571).³¹ Smokeless-powder and black-powder loading both conformed to the same basic loading procedures:

The major operations involved in the bag-loading plants are the cutting and sewing of cloth bags of various sizes and the loading of these bags with specific amounts of smokeless powder for propellant charges or black powder for igniter charges.

In the bag-making department the cloth is spread and cut into specified sizes and shapes, depending upon the type of charge which is to be loaded. After identification of the charge has been printed on these pieces of cloth, they are sent to the sewing room to be made into bags by seaming on power sewing machines. An opening is left in the bag for pouring in the powder charge.

The bag-loading lines are made up of buildings for the actual loading of the gunpowder and a number of widely spaced and barricaded storage magazines. The bag-loading buildings are divided into small rooms with thick concrete walls between them for safety of the operators. In these small rooms, each having only a limited number of operators, the explosive powder is carefully weighed and poured into the bags which have been transferred from the bag-making department. The bag is then closed on a sewing machine and is ready for final inspection and packing. For certain types of ammunition, several bags are tied together before packing,³² to form a charge made up of several increments.

In the summer of 1943 the New River Unit was converted for waterproofing trench mortar increments, ". . . a process almost identical with that used to insert medicine pills into cellophane strips."³³ Bag loading resumed in August 1944 and continued until the end of the war.³⁴ Although the New River Unit was expanded during the war, the processes used in the new areas were simple modifications of those used in the earlier portions of the plant.

POST-WORLD WAR II

As World War II drew to a close, production at the RAAP slowed, then stopped on September 21, 1945. The operating contract was terminated and the plant placed in standby status.

The following summer the Radford Unit was one of fifteen plants selected to produce ammonium nitrate for fertilizer. The H. K. Ferguson Company of Cleveland performed the necessary modifications to the acid plant, and Hercules Powder Company operated the plant. Fertilizer production continued until April 1949, when the plant was re-modified for the manufacture of smokeless powder and placed in standby condition.³⁵

The entire New River Unit was declared surplus in September 1945. In April 1946 the magazine areas were withdrawn from surplus status and placed in standby. The following month the unit was designated a sub-post of the RAAP, a designation it held until February 1950 when it became an integral

part of the installation. Between December 1946 and January 1948, large parcels of the plant manufacturing areas were sold.³⁶

KOREAN WAR

With the increase of tensions in Korea, Hercules Powder Company again was designated operating contractor for RAAP and was directed to begin limited production of rocket powder.³⁷ When it became apparent that largescale operations would be required, the plant underwent major rehabilitation of all operating areas. Hayes, Seay, Mattern and Mattern of Roanoke, Virginia, were engineers for the rehabilitation while the J. A. Jones Construction Company of Charlotte, N.C., was the contractor.³⁸

The primary product of this period, in addition to single-base propellants, was rocket propellant. Both Pilot Plants "A" and "B" were expanded and converted to manufacture rocket powder. Powder Line "A" also was modified to support this effort. New construction included facilities for casting rocket propellants, and facilities for manufacture of triple-based powders and nitroglycerin.³⁹

This same period saw a "clean-up" of surplus buildings. Between 1953 and 1956 nearly 100 buildings, including the entire pentolite and TNT manufacturing areas, were demolished.⁴⁰

RAAP remained active, but at a greatly reduced level, following cessation of the Korean War. The only significant event during the next few years

was the sale of the remaining manufacturing areas at the New River Unit in 1962-63.⁴¹

VIETNAM WAR TO THE PRESENT

Production of various propellants began increasing in 1962 to support the Vietnam War and rose to a peak in 1968. No significant changes were required in production facilities or techniques.

A major modernization plan, started in 1968, led to the construction of several new facilities. The first project was a set of three continuous automated TNT lines completed in 1968.⁴² Facilities completed between 1972 and 1975 include a sulphuric acid regenerator, several nitric acid/sulfuric acid concentrators (NAC/SACs), a continuous nitrocellulose nitration facility, an ammonia oxidation plant, a continuous automated single-base line (CASBL), and a main administration building.⁴³ A continuous automated multiple-base line (CAMBL) is nearing completion.

Two major explosions occurred during the 1970s. In May 1974 the "A" line of the TNT plant exploded, causing significant damage to the "B" and "C" lines as well. Nitroglycerin Plant 2 exploded in January 1978, leading to reactivation of Nitroglycerin Area 1.⁴⁴

As a result of modernization, expansion, and the continued demolition of excess buildings, the RAAP presents primarily a Korean War appearance with

modern intrusions. RAAP currently is active in all areas except the "A" nitrocellulose and powder lines.

NOTES

1. Sidney D. Kirkpatrick, "Mid-West Builds Biggest U. S. Powder Plant," Chemical & Metallurgical Engineering, 48 (April 1941), 74. The dismantling of the American munitions industry after World War I is discussed in Jules Bebie, "Making Explosives for World War II," Chemical & Metallurgical Engineering, 48 (October 1941), 76. As Secretary of War Henry L. Stimson noted in 1943, "We didn't have enough powder in the whole United States [in 1940] to last the men we now have overseas for anything like a day's fighting"; see Harry C. Thomson and Lida Mayo, The Ordnance Department: Procurement and Supply (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1960), p. 104.
2. The other two powder plants were the (Charleston) Indiana Ordnance Works, completed in 1941, and the Alabama Ordnance Works, completed in 1942; see Kirkpatrick, 73; Vincent B. Smith, "Ten-Month Time Limit Spurs 21,000 Construction Workers on \$41,000,000 Powder Plant," Construction Methods, 23 (April 1941), 426-456; Lenore Fine and Jesse A. Remington, The Corps of Engineers: Construction in the United States (Washington, D.C.: Office of the Chief of Military History, United States Army, 1972), p. 340.
3. The conformance of the RAAP site to general selection criteria is noted in Douglas M. Considine, "From the Ground Up," Scientific American, 166 (June 1942), 278-279; a more detailed discussion of the RAAP site selection is provided in "Plant History, Radford Ordnance Works, Inception thru 1941," Vol. I, p. 174, unpublished report prepared by the U.S. Army Corps of Engineers, n.d., RAAP Administrative Archives.
4. Smith, p. 42.
5. "Commemorating Twenty Five Years of Operation -- Radford Army Ammunition Plant," n.d. (c. 1966), Unpublished report in RAAP Administrative Archives.
6. "Historical Report of New River Ordnance Plant, Government-Owned, Hercules Powder Company Operated, Dublin, Virginia, December 17, 1940, through 1945," pp. 27, 41-42, unpublished report, n.d., in RAAP Administrative Archives.

7. "War Department Industrial Facilities Inventory, Radford Ordnance Works, Radford, Virginia," Vol. II, Part II, Section I, p. 1, n.d., unpublished report prepared by U.S. Army Corps of Engineers, in Rock Island Arsenal Historical Office.
8. "Plant History, Radford Ordnance Works," Vol. II, p. 729.
9. "War Department Industrial Facilities Inventory, ROP," Vol. II, Part I, Section 5, pp. 1-38.
10. "Plant History, Radford Ordnance Works," Vol. II, p. 721, and "Historical Report of NROP, December 17, 1940, through 1945", p. 27.
11. "War Department Industrial Facilities Inventory, ROP," Volume II, map.
12. "Historical Report of Radford Ordnance Works, 1940-1945," p. 215, unpublished report prepared by RAAP staff, n.d., RAAP Administrative Archives.
13. Smith, p. 48, and field survey by Robert Mack, MacDonald and Mack Partnership, December 1983.
14. "Building for Defense . . . Powder Ahead of Schedule," Architectural Forum, 74 (June 1941), 432-434.
15. "War Department Industrial Facilities Inventory, ROP," Vol. II; and "Historical Report of Radford Ordnance Works, 1940-1945," pp. 203-204.
16. "Plant History, Radford Ordnance Works," Vol. II, p. 733.
17. "Historical Report of New River Ordnance Plant," pp. 35-36.
18. "War Department Industrial Facilities Inventory Report, New River Ordnance Plant, Addendum No. 1," Part II, Section 4, pp. 3-4, unpublished report prepared by the U.S. Army Corps of Engineers, September 1945, in Rock Island Arsenal Historical Office.
19. "History of Hoosier Ordnance Plant, Construction, n.p., n.d., unpublished report in Indiana Army Amunition Plant Archives.
20. Chief of Ordnance, "Manufacture of Smokeless Powder," Military Explosives (Washington, D.C.: War Department, Technical Manual No. 902900, August 29, 1940), pp. 4-38. Also see Robert G. Skerret, "Smokeless Powder for Our Navy," Compressed Air Magazine, 50 (February 1945), 39-45.
21. Interview with James Nelson, Chief of Standby and Layaway Division, RAAP, December 1983.
22. RAAP was adapted for the use of wood pulp in place of cotton, necessitating the construction of a pulp-shredder building for each nitrocellulose line. See "Hercules Adapts Wood Pulp for Powder," Paper Trade Journal, 115 (December 24, 1942), 18.

23. "Making Smokeless Powder at Radford, Va.," Chemical & Metallurgical Engineering, 48 (April 1941), 103.
24. Guy B. Taylor and others, "Manufacture of Nitric Acid by the Oxidation of Ammonia," Industrial and Engineering Chemistry, 23 (August 1, 1931), 860-865.
25. "IAAP [Indiana Army Ammunition Plant] Chemical Division Manual," Section II (Acid), p. 4, unpublished, n.d., ICI Americas, Inc., Archives, Indiana Army Ammunition Plant.
26. "Propellant Production at Sunflower Army Ammunition Plant," Section C, pp. 24-C through 29-C, provides a detailed description of the manufacture of nitroglycerin.
27. Smith, pp. 53-54.
28. "A Brief History of Radford Ordnance Works," unidentified attachment to "Historical Report of Radford Arsenal, Radford, Virginia, 2 September 1945 through 30 June 1951," unpublished report prepared by Hercules and RAAP staff, February 18, 1953, in RAAP Administrative Archives.
29. "War Department Industrial Facilities Inventory, ROP," Vol. II, Part I, Section 5, pp. 35-36.
30. "Historical Report of New River Ordnance Plant," p.36.
31. "War Department Industrial Facilities Inventory Report, New River Ordnance Plant," map attachment, unpublished report prepared by U.S. Army Corps of Engineers, March 1944, in Rock Island Arsenal Historical Office..
32. "Hourly Earnings in the Ammunition-Loading Industry, 1944," Monthly Labor Review, 60 (April 1945), pp. 840-841.
33. "A Brief History of ROW," in "Historical Report of Radford Arsenal.
34. "War Department Industrial Facilities Inventory Report, NROP, Addendum No. 1," Part I, Section 1.
35. "Historical Report of Radford Arsenal," p. 2.
36. Ibid., pp. 3-4, and "Basic Unit History, 1 January 1965 through 31 December 1967," Section I, p. 2, unpublished report prepared by Hercules and RAAP staff, September 9, 1968, in RAAP Administrative Archives.
37. "Historical Report of Radford Arsenal," p. 2.
38. "Semiannual Historical Summary, Radford Arsenal, 1 July 1951 thru 31 December 1951," pp. 28-29, unpublished report prepared by Hercules and RAAP staff, April 24, 1952, in RAAP Administrative Archives.

39. "Semiannual Historical Report of Radford Arsenal, 1 January 1952 through 30 June 1952," unpublished report prepared by Hercules and RAAP staff, October 13, 1952, in RAAP Administrative Archives; and "Semiannual Historical Report of Radford Arsenal, 1 July 1953 through 31 December 1953," p. 68, unpublished report prepared by Hercules and RAAP staff, April 12, 1954, in RAAP Administrative Archives.
40. "Semiannual Historical Report of Radford Arsenal, 1 July 1954 through 31 December 1954," pp. 1, 21, unpublished report prepared by Hercules and RAAP staff, n.d., in RAAP Administrative Archives; "Semiannual Historical Report of Radford Arsenal, 1 July 1955 through 31 December 1955," unpublished report prepared by Hercules and RAAP staff, n.d., in RAAP Administrative Archives; and "Semiannual Historical Report of Radford Arsenal, 1 July 1956 through 31 December 1956," unpublished report prepared by Hercules and RAAP staff, n.d., in RAAP Administrative Archives.
41. "AMC Installation and Activity Information Summary, Radford Army Ammunition Plant," p. 4, unpublished report prepared by RAAP staff, July 1, 1972, in RAAP Administrative archives.
42. Ibid., p. 4.
43. "DARCOM Installation and Activity Brochure, Radford Army Ammunition Plant," p. 2, unpublished report prepared by RAAP staff, June 30, 1980, in RAAP Administrative Archives.
44. Ibid., p. 2.

Chapter 3

PRESERVATION RECOMMENDATIONS

BACKGROUND

Army Regulation 420-40 requires that an historic preservation plan be developed as an integral part of each installation's planning and long-range maintenance and development scheduling.¹ The purpose of such a program is to:

- . Preserve historic properties to reflect the Army's role in history and its continuing concern for the protection of the nation's heritage.
- . Implement historic preservation projects as an integral part of the installation's maintenance and construction programs.
- . Find adaptive uses for historic properties in order to maintain them as actively used facilities on the installation.
- . Eliminate damage or destruction due to improper maintenance, repair, or use that may alter or destroy the significant elements of any property.
- . Enhance the most historically significant areas of the installation through appropriate landscaping and conservation.

To meet these overall preservation objectives, the general preservation recommendations set forth below have been developed:

Category I Historic Properties

All Category I historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for nomination regardless of age. The following general preservation recommendations apply to these properties:

- a) Each Category I historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category I historic properties should not be altered or demolished. All work on such properties shall be performed in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).
- b) An individual preservation plan should be developed and put into effect for each Category I historic property. This plan should delineate the appropriate restoration or preservation program to be carried out for the property. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulation. Until the historic preservation plan is put into effect, Category I historic properties should be maintained in accordance with the recommended approaches of the Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings² and in consultation with the State Historic Preservation Officer.

- c) Each Category I historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.³ When no adequate architectural drawings exist for a Category I historic property, it should be documented in accordance with Documentation Level I of these standards. In cases where standard measured drawings are unable to record significant features of a property or technological process, interpretive drawings also should be prepared.

Category II Historic Properties

All Category II historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for nomination regardless of age. The following general preservation recommendations apply to these properties:

- a) Each Category II historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category II historic properties should not be altered or demolished. All work on such properties shall be performed in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation

(ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

- b) An individual preservation plan should be developed and put into effect for each Category II historic property. This plan should delineate the appropriate preservation or rehabilitation program to be carried out for the property or for those parts of the property which contribute to its historical, architectural, or technological importance. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulations. Until the historic preservation plan is put into effect, Category II historic properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings⁴ and in consultation with the State Historic Preservation Officer.
- c) Each Category II historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.⁵

Category III Historic Properties

The following preservation recommendations apply to Category III historic properties:

- a) Category III historic properties listed on or eligible for nomination to the National Register as part of a district or thematic group should be treated in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800). Such properties should not be demolished and their facades, or those parts of the property that contribute to the historical landscape, should be protected from major modifications. Preservation plans should be developed for groupings of Category III historic properties within a district or thematic group. The scope of these plans should be limited to those parts of each property that contribute to the district or group's importance. Until such plans are put into effect, these properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings⁶ and in consultation with the State Historic Preservation Officer.

- b) Category III historic properties not listed on or eligible for nomination to the National Register as part of a district or thematic group should receive routine maintenance. Such properties should not be demolished, and their facades, or those parts of the property that contribute to the historical landscape, should be protected from modification. If the properties are unoccupied, they should, as a minimum, be maintained in stable condition and prevented from deteriorating.

HABS/HAER Documentation Level IV has been completed for all Category III historic properties, and no additional documentation is required as long as they are not endangered. Category III historic properties that are endangered for operational or other reasons should be documented in accordance with HABS/HAER Documentation Level III, and submitted for inclusion in the HABS/HAER collections in the Library of Congress.⁷ Similar structures need only be documented once.

CATEGORY I HISTORIC PROPERTIES

There are no Category I historic properties at the RAAP.

CATEGORY II HISTORIC PROPERTIES

There are no Category II historic properties at the RAAP.

CATEGORY III HISTORIC PROPERTIES

There are no Category III historic properties at the RAAP.

NOTES

1. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).
2. National Park Service, Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983 (Washington, D.C.: Preservation Assistance Division, National Park Service, 1983).
3. National Park Service, "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines," Federal Register, Part IV, 28 September 1983, pp. 44730-44734.
4. National Park Service, Secretary of the Interior's Standards.
5. National Park Service, "Archeology and Historic Preservation."
6. National Park Service, Secretary of the Interior's Standards.
7. National Park Service, "Archeology and Historic Preservation."

BIBLIOGRAPHY

Published Sources

- Bebie, Jules. "Making Explosives for World War II." Chemical & Metallurgical Engineering, 48 (October 1941), 76-78. Excellent overview of explosives industry created under National Defense Project.
- "Building for Defense . . . Powder Ahead of Schedule." Architectural Forum, 74 (June 1941), 432-4.
- Chief of Ordnance. "Manufacture of Smokeless Powder." Military Explosives. Washington, D.C.: War Department, Technical Manual No. 902900, August 29, 1940.
- Considine, Douglas M. "From the Ground Up." Scientific American, 166 (June 1942), 278-279. Discusses development of American World-War-II munitions network.
- Fine, Lenore, and Remington, Jesse A. The Corps of Engineers: Construction in the United States. Washington, D.C.: Office of the Chief of Military History, United States Army, 1972. Standard work on Corps's munition construction projects during World War II.
- "First Government Munitions Plant." Business Week, March 22, 1941, 17. Briefly describes opening of RAAP.
- Hardy, R. E. "Producing Smokeless Powder by 1942 Methods." Chemical & Metallurgical Engineering, 49 (April 1942), 76-79. Detailed description of smokeless-powder operations.
- "Hercules Adapts Wood Pulp for Powder." Paper Trade Journal, 115 (December 24, 1942), 18.
- Higham, Robin, ed. A Guide to the Sources of United States Military History. Hamden, Conn.: Archon Books, 1975.
- Hoy, Suellen M. and Robinson, Michael C., eds. Public Works History in the United States. Nashville: American Association for State and Local History, 1982.
- Jessup, John E. and Coakley, Robert W. A Guide to the Study and Use of Military History. Washington, D.C.: U.S. Government Printing Office, 1979.
- Kirkpatrick, Sidney D. "Mid-West Builds Biggest U.S. Powder Plant." Chemical & Metallurgical Engineering, 48 (April 1941), 73-76.

"Making Smokeless Powder at Radford, Va." Chemical & Metallurgical Engineering, 48 (April 1941), 103. Provides detailed description of production processes.

National Park Service. "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines." Federal Register, Part IV (28 September 1983), 44730-44734.

_____. How to Complete National Register Forms. Washington, D.C.: U.S. Government Printing Office, 1977.

_____. Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983. Washington, D.C.: Preservation Assistance Division, National Park Service, 1983.

Nunes, Don. "Defying Death." Washington Post, August 15, 1982. Describes 1978 explosion at RAAP nitroglycerin plant.

"Radford Plant Opens Three Months Ahead of Schedule." Engineering News Record, 126 (March 27, 1941), 38. Describes dedication ceremony and physical layout of RAAP.

Skerret, Robert G. "Smokeless Powder for Our Navy." Compressed Air Magazine, 50 (February 1945), 39-45. Good historical summary of development of smokeless-powder manufacture.

Smith, Vincent B. "Ten-Month Time Limit Spurs 21,000 Construction Workers on \$41,000,000 Powder Plant." Construction Methods, 23 (April 1941), 426-456. Describes construction of RAAP.

"Smokeless Powder." Chemical & Metallurgical Engineering, 49 (April 1942), 110-113. Provides excellent flow diagram of manufacturing process.

Taylor, Guy B., and others. "Manufacture of Nitric Acid by the Oxidation of Ammonia." Industrial and Engineering Chemistry, 23 (August 1, 1931), 860-865. First published description of du Pont pressure process.

Thomson, Harry C., and Mayo, Lida. The Ordnance Department: Procurement and Supply. Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1960.

United States Army Armament Materiel Readiness Command. Catalog of Common Sources, Fiscal Year 1983. No. pl.: Historical Office, AMCCOM, Rock Island Arsenal, Rock Island, Ill.

Unpublished Sources

- "AMC Installation and Activity Information Summary, Radford Army Ammunition Plant." July 1, 1972. RAAP Administrative Archives. Provides information concerning plant development 1964-72.
- "Annual Plant History for Calendar Year 1968 at Radford Army Ammunition Plant." March 14, 1969. RAAP Administrative Archives. Includes extensive discussion of new TNT facilities.
- "Basic Unit History, Radford Army Ammunition Plant." September 9, 1968. RAAP Administrative Archives. Provides summary of development from plant inception to December 1964 and a more detailed account of activities in 1965.
- "Commemorating Twenty Five Years of Operation -- Radford Army Ammunition Plant." N.d. (c. 1966). RAAP Administrative Archives.
- "DARCOM Installation and Activity Brochure, Radford Army Ammunition Plant." June 30, 1980. RAAP Administrative Archives. Provides information concerning plant development 1973-80.
- Historic American Buildings Survey/Historic American Engineering Record, National Park Service. Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures. Draft, 1982.
- "Historical Report of New River Ordnance Plant, Government-Owned, Hercules Powder Company Operated, Dublin, Virginia, December 17, 1940 through 1945." N.d. RAAP Administrative Archives. Detailed account of construction and early technology of RAAP bag-loading plant. Also includes description of earlier Hercules powder plant operations.
- "Historical Report of Radford Ordnance Works, 1940 - 1945." 3 vols. N.d. RAAP Administrative Archives. Provides extensive information concerning early plant development.
- "Historical Report of Radford Arsenal, Radford, Virginia, 2 September 1945 through 30 June 1951." February 18, 1953. RAAP Administrative Archives. Provides developmental information for period indicated. An unidentified attachment, "A Brief History of Radford Ordnance Works," describes early development and expansion of the RAAP.
- "Historical Summary, Radford Arsenal, 2 September 1945 through 30 June 1951." N.d. RAAP Administrative Archives.
- "History of Hoosier Ordnance Plant, Construction." N.d. Indiana Army Ammunition Plant Archives.

- "Indiana Army Ammunition Plant Chemical Division Manual." N.d. ICI Americas, Inc., Archives, Indiana Army Ammunition Plant.
- "Modernization Engineering Report for U. S. Army Ammunition Plants." Vol. 4. Report prepared by Kaiser Engineers for U.S. Army Munitions Command, Dover, N.J., 1970. AMCCOM Historical Office Archives, Rock Island Arsenal.
- "Plant History for Fiscal Year 1971 at Radford Army Ammunition Plant." N.d. RAAP Administrative Archives.
- "Plant History, Radford Ordnance Works, Inception thru 1941." 2 vols. Prepared by U.S. Army Corps of Engineers, n.d. RAAP Administrative Archives. Provides in-depth information concerning initial development of RAAP.
- "Propellant Production at Sunflower Army Ammunition Plant." N.d. Sunflower Army Ammunition Plant Archives. Provides good description of manufacturing processes for various explosives.
- Radford Army Ammunition Plant Installation Map. C. 1980. RAAP Engineering department. Covers only Radford unit.
- Radford Army Ammunition Plant - New River Installation Map. C. 1980. RAAP Engineering department.
- Radford Army Ammunition Plant - New River Real Property Inventory. Computer printout, March 31, 1982. RAAP Real Property Office Archives.
- Radford Army Ammunition Plant Real Property Inventory. Computer printout, March 31, 1982. RAAP Real Property Office Archives. Covers only Radford unit of the RAAP.
- "Semiannual Historical Summary of Radford Arsenal, 1 July 1951 thru 31 December 1951." Report prepared by Hercules and RAAP staff, April 24, 1952. RAAP Administrative Archives.
- "Semiannual Historical Report of Radford Arsenal, 1 January 1952 through 30 June 1952." Report prepared by Hercules and RAAP staff, October 13, 1952. RAAP Administrative Archives.
- "Semiannual Historical Report of Radford Arsenal, 1 July 1953 through 31 December 1953." Report prepared by Hercules and RAAP staff, April 12, 1954. RAAP Administrative Archives.
- "Semiannual Historical Report of Radford Arsenal, 1 July 1954 through 31 December 1954." Report prepared by Hercules and RAAP staff, n.d. RAAP Administrative Archives.
- "Semiannual Historical Report of Radford Arsenal, 1 July 1955 through 31 December 1955." Report prepared by Hercules and RAAP staff, n.d. RAAP Administrative Archives.

"Semiannual Historical Report of Radford Arsenal, 1 July 1956 through 31 December 1956." Report prepared by Hercules and RAAP staff, n.c. RAAP Administrative Archives.

Voight, William, Jr. "The Ordnance Organization in World War II." Report prepared for U.S. Ordnance Department, 1945. On microfiche, AMCCOM Historical Office, Rock Island Arsenal. Brief descriptions of government-owned, contractor-operated munitions plants constructed during World War II.

"War Department Industrial Facilities Inventory Report, New River Ordnance Plant." March 1944. Prepared by U.S. Army Corps of Engineers. AMCCOM Historical Archives, Rock Island Arsenal.

"War Department Industrial Facilities Inventory Report, New River Ordnance Plant, Addendum No. 1." September 1945. Prepared by U.S. Army Corps of Engineers. AMCCOM Historical Archives, Rock Island Arsenal.

"War Department Industrial Facilities Inventory, Radford Ordnance Works." March 1944. Prepared by U.S. Army Corps of Engineers. AMCCOM Historical Archives, Rock Island Arsenal.

"War Department Industrial Facilities Inventory Report, Radford Ordnance Works." December 1945. Prepared by U.S. Army Corps of Engineers. AMCCOM Historical Archives, Rock Island Arsenal.



Appendix A Radford Ammunition Plant

HAER No. VA-37

DEPARTMENT OF THE ARMY

RADFORD ARMY AMMUNITION PLANT

P. O. BOX 2

RADFORD, VIRGINIA 24141

January 10, 1984

REPLY TO
ATTENTION OF

Safety Office

Mr. Robert C. Mack
MacDonald and Mack Partnership
215 Grain Exchange Building
Minneapolis, Minnesota 55415

Dear Mr. Mack:

This letter is to confirm our discussion that certain areas of the installation would not be available for inspection due to security and/or safety reasons during your visit to Radford Army Ammunition Plant on December 7-9, 1983, concerning the DARCOM Historic Survey, NPS Contract No. CX-0001-2-0033.

For safety reasons, due to the sensitivity of the manufacturing process in certain locations of the installation, it was not permissible to expose transients in any operating buildings due to regulated personnel load limits. Areas such as CASBL and CAMBL are new modernized facilities and have no historical value at this time.

Also, cameras are not permitted in operating or contaminated buildings due to the volatile nature of the atmosphere which could be ignited by a flash from a camera or a spark from a battery-operated shutter. Also, some of the buildings contained Hercules proprietary items.

Your cooperation and understanding of the restrictions were most appreciated. Please feel free to contact Ms. Frances Selnow, RAAP Administrative Officer, if further assistance is required for this survey.

Sincerely,

Douglas M. Day
Safety Manager